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WEST AFRICAN MAIZE RUST RESEARCH UNIT

FIRST ANNUAL REPORT

1953

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FOREWORD

Up to 1949 West Africa, in common with the rest of the world, had *Puccinia sorghi* as a not very important rust on its maize. Nobody bothered about it. In 1949, F. C. Deighton found a rust causing an epidemic on maize in Sierra Leone. It was first taken to be the cosmopolitan *P. sorghi* but was later found to be *P. polysora*. There is no evidence that *P. polysora* occurred anywhere else in Africa up to that time. Hughes' collections made in the Gold Coast in 1949 were all of *P. sorghi* and he could not have failed to find *P. polysora* had it been there in the epidemic form in which it occurred a year later. In 1950 and 1951 there were maize rust epidemics all over the wetter parts of West Africa and all were due to *P. polysora*, the " Southern Corn Rust " of America. Damage was severe, particularly on late sown crops. Once established in Africa the spread of this disease was to be expected and it did not take long to reach East Africa and the islands of Mauritius and Madagascar.

The destruction wrought by this disease was spectacular and alarming. Bearing in mind the enormous importance of the maize crop in parts of East and South Africa a feeling of apprehension for the future was natural. Now that we know more about this rust there is less cause for alarm. It has been found to require a high temperature and a high humidity in order to flourish so that in the major maize-growing areas it seems to find conditions too cool and dry for its liking. There are, nevertheless, large areas where the disease must be regarded as an important one, and, should it eventually cross the Indian Ocean as it crossed the Atlantic, fresh areas will be involved.

It is a great pleasure to write this foreword to the First Annual Report of the West African Maize Rust Research Unit. This small unit, with a staff of only two scientists, has made notable contributions towards solving the problem which came so suddenly. It is also a pleasure to acknowledge the very generous help in this work given by the Nigerian Department of Agriculture, amongst whose collection of maize varieties were found some from Central America which show resistance to *P. polysora*. Without this essential breeding material it would have been impossible to progress so quickly to the stage of multiplication of selected seed.

When the West African Maize Rust Research Unit was established it was envisaged that although the rust was the first problem the ultimate aim should be to produce varieties having a general superiority over those currently grown. In the breeding programme attention cannot be paid solely to rust but other characters must be given attention including such problems as stem borer susceptibility, other diseases and yielding capacity. It is not therefore to be concluded that because rust resistance has been demonstrated the end of the work of the Unit is in sight. In fact, much work remains to be done, including the task of maintaining rust resistant stocks.

D. RHIND,

Formerly Secretary for Agricultural & Forestry Research,
West African Inter-Territorial Secretariat.

12*th May*, 1954.
COLONIAL OFFICE, LONDON.

SENIOR SCIENTIFIC OFFICER'S REPORT

This report is a brief record of the results of the first year's work of the West African Maize Rust Research Unit. The events leading to the formation of this unit have been outlined in the foreword and the history of the epidemic of rust on maize, hitherto an unknown disease in West Africa, is considered in the first part of the research notes. (Cammack, 1954.)

A primary requisite of the Maize Rust Research Scheme was that the work should proceed as rapidly as possible to find both palliative measures and a permanent solution to the problem of the recent epidemics. It is this consideration which has dictated the pattern of the work. An appreciation of the problem was available in the form of a memorandum by Mr. D. Rhind (at that time Secretary for Agriculture and Forestry Research, West African Inter-Territorial Secretariat) and work on the investigation of control measures for the disease had been conducted prior to the establishment of the Unit by officers of the Gold Coast and Nigerian Departments of Agriculture.

STAFF

A nucleus technical staff was seconded to the Unit by the Western Region, Nigeria, Department of Agriculture and this was augmented by local recruitment. Difficulty was encountered in recruiting junior technical staff as all boys possessing the school certificate qualification continue on to further education. It has been possible to employ undergraduates from the University College, Ibadan, during the summer vacations and these have been a valuable supplement to the technically trained staff of the Unit. Staff training has therefore been an important part of the first year's work and it is continuing and expanding to accommodate assistants from the Departments of Agriculture so that the extension work of the Unit may be properly conducted.

BUILDINGS

The Unit has been housed and provided with laboratories at Ibadan by the Central Research Organisation of the Nigerian Department of Agriculture, and additionally the varied and indispensable services of the Department, both technical and administrative, have been placed at the Unit's disposal. Land has been available both at Moor Plantation, Ibadan, Nigeria; Kumasi, Gold Coast, and on Agricultural Department stations as required.

The work of the Unit in the Gold Coast has been supervised by a Senior Agriculture Officer, who was responsible for studies in rust in the Gold Coast prior to the formation of the unit. This officer and two Gold Coast Technical Officers have paid visits to Moor Plantation, the latter on secondment for part of the year. Liaison with Sierra Leone and the Gambia has been more difficult. However, the needs of these two territories are not so pressing as those of the aforementioned.

In the course of the year, the Unit has constructed a working shelter and an air conditioned store (200 ft. floor space) capable of maintaining a temperature of 55°F. and this will, in future, provide a valuable asset to the Unit's equipment. Difficulties have been experienced in deciding on the type and construction of an appropriate glass-house for the work, and preliminary experiments on this are still being conducted.

APPARATUS

As with the formation of any new organisation, many temporary difficulties have been experienced through lack of apparatus, many items of which are not available in Nigeria.

MATERIALS FOR BREEDING PURPOSES

In the latter part of 1951, requests were sent by Mr. Rhind and the Nigerian Department of Agriculture to a number of countries for supplies of seed which might prove resistant to *Puccinia polysora* and particularly noteworthy among the batches of seed received was a group of 25 varieties, lines and hybrids sent by the Rockefeller Institute Research Centre, Mexico City. During the course of the year other supplies have been received from areas threatened by the disease (East, Central and South Africa and India) for reports on the susceptibilities of the varieties grown in these countries. The object was to deduce the magnitude of the threat to these countries.

Tests on these have been published in brief elsewhere (Stanton, 1953) and are reported in the first paper of the research report, " Sources of resistance to the maize rust."

PLANNING THE WORK

At the outset of this work, it was considered justifiable to regard the problem of this epidemic of rust in West Africa as likely to conform to the normal behaviour of other important foliicolous rusts of cereals, although, as it is discussed elsewhere in this report, this rust does not appear to have a complete cycle. The severity of the epidemic indicated a general high susceptibility of the host. This did not preclude the possibility of the presence of resistant genotypes in the population. The significance of their possible existence or absence is discussed (by Stanton and Cammack, 1953a). The work is, therefore, being divided into two stages in order, firstly, to observe the epidemic and formulate interim methods for its control and secondly to breed resistant varieties. To date the work has largely been concerned with the first stage, whilst giving due attention to the preliminary testing of material for the second stage. The mycologist is still investigating the biology of the uredospore which appears to differ markedly in its behaviour from that of uredospores of temperate graminaceous *Puccinia* species.

In investigations on the identity of the pathogens attacking maize, the mycologist has found a number which contribute to losses in yield either directly or as secondary pathogens attendant upon the attack of *Puccinia polysora*. Of particular importance is *Helminthosporium turcicum* Pass, and work on this disease is being commenced in 1954.

Similarly, from a breeding view point, it has been found necessary to consider other properties of West African maizes and these are discussed by Stanton under "Factors affecting the yield of maize in West Africa."

VISITS, VISITORS, ETC.

In December, 1952, Dr. W. R. Stanton paid a brief visit to Sierra Leone and the Gold Coast to obtain first hand information on the problems of the disease and to discuss how best the Unit might help these territories. It was agreed that for Sierra Leone, it would be sufficient for the Unit to provide suitable varieties and lines for the production of hybrids. The problems in the Gold Coast, seemed similar to those in Nigeria and equivalent extension studies were conducted in both territories. In August, 1953, Dr. W. R. Stanton was given the opportunity of visiting the International Genetical Congress and Research Stations in Italy. This enabled him to meet and discuss the problems of the Unit's work with leading authorities on maize breeding and the genetics of rust resistance from various parts of the world, particularly from North and South America.

Visits to the Unit have been numerous. Of particular value was a series of visits paid by the members of the Food and Agricultural Organisation's Course on Agricultural Statistics in July of last year. Dr. Panse, Statistical Adviser to the Indian Agricultural Research Council, made very valuable suggestions on the various stages of maize trials for rust resistance in the light of his experience of wheat rust work in India.

SEED LIST

As a supplement to this report a variety description list is given of some of the more important lines used in the work. (Appendix iv.)

It is to be hoped that a standardized method of description of maize varieties will be available in the future and the Unit is experimenting with forms of charts for description purposes based on those used by the Food and Agricultural Organisation for the "World List of Genetic Stocks of Rice, Wheat, etc."

SOURCES OF RESISTANCE TO THE MAIZE RUST *PUCCINIA POLYSORA* UNDERW.

W. R. STANTON AND R. H. CAMMACK

(This paper has been inserted as a report on the first method used to select and assess polysora resistant maizes. As an emergency method it has proved very satisfactory and material selected on this system has been shown to be resistant under other systems of testing. The method described here measures resistance to pustule formation and a revised scale is being investigated which will take into account genes which affect pustule development. Differences in pustule development are being investigated by the mycologist.)

Through the co-operation of the West African Inter-Territorial Secretariat (Agriculture and Forestry Department) and the Department of Agriculture of the Nigerian Government a large number of imported types of maize have been made available for testing for rust resistance and other agronomic properties by the Unit. A preliminary report on this has been given (Stanton and Cammack, 1953a). Much material remains untested as the samples received require multiplication before they can be properly assessed.

GREEN-HOUSE ASSESSMENTS

Several seedling methods of testing rust resistance were tried. The seed was surface sterilized with 1% mercuric chloride for 2 minutes and then thoroughly washed in sterile water. They were sown in 9-in. diameter wicker baskets filled with steam sterilized soil. Sixteen seedlings were raised per basket. On the emergence of the third true leaf, inoculation was carried out. Three methods were found to initiate infection.

(*a.*) Dry dusting method

Uredospores were removed from infected maize by a dry camel's hair brush. These were dusted over the upper half of the first, second and third leaves of each seedling. Following dusting, the plants were lightly sprayed with water from an atomizer.

After spraying, the seedlings were covered with a cellophane hood for 36 hours. (Later replaced by polythene sleeving as cellophane deteriorated rapidly and encouraged moulds —(Stanton, 1951). The hood was then removed and the seedling baskets left standing in conditions of high humidity and light intensity in the green-house.

(*b.*) Spore smearing method (Newton, 1952)

The upper half of the first, second and third leaves were lightly passed through the thumb and first finger to remove the bloom, and then inoculated by spreading on a thin, uniform layer of spores with the flat side of a scalpel. The seedlings were afterwards sprayed with water from an atomizer and covered with a cellophane hood as before.

(*c.*) Spraying with a spore suspension

A dense aqueous suspension of uredospores was obtained by shaking pieces of heavily infected maize leaf in water. This suspension was then applied with a wide nozzled sprayer, the quantity being just sufficient to cover the leaves of the seedlings with a uniform coating of little droplets of spore suspension. The seedlings were covered with cellophane for 48 hours.

Of the three methods, best results were obtained from method (*b*) ; method (*a*) and (*c*) being less effective in that order. From the work to date on seedling inoculations the following points have emerged :—

(i) Application of spores to a dry leaf surface as recorded by Manners (1950) is desirable. This was exemplified by the frequent failure of method (*c*). Spraying the leaf surface prior to inoculation also resulted in unsatisfactory infections being obtained.

(ii) After inoculation and covering with cellophane, best infections are obtained by keeping the seedlings under conditions of high light intensity and high humidity.

(iii) The best infection court is the upper third of the young leaf.

(iv) The use of method (*b*) gave good infections which showed a close correlation with the quantitative infection of the mature plants in the field. Eighty-seven varieties were subjected to seedling tests in January 1953 using method (*b*). The results obtained from these varieties when assessed in the seedling stage agreed approximately with the quantitative rust intensities obtained in the field during the 1953 main season crop.

Seedling tests in the greenhouse were suspended, however, after these preliminary trials, as the results obtained were found to vary greatly with temperature and light conditions. With the existing facilities it was found impossible to produce the constant conditions necessary for critical work and for strain differentiation.*

FIELD ASSESSMENT

A method was therefore devised to enable large numbers of plants in the field to be assessed for their reaction to rust by relatively unskilled observers (Stanton and Cammack, 1953a). This assessment key was divided into five categories of rust intensity listed below. (Table I.)

Table I—**Key for the assessment of maize rust intensity**

Degree of rust intensity.	
Class **0**	The host leaf green and healthy. Necrosis completely absent. Chlorotic spots may be present.
Class **1**	Single, isolated pustules distributed over the surface of the leaf. Never in clusters.
Class **2**	Small groups of pustules distributed over the surface and generally interspaced with an occasional single pustule. The leaf still appears healthy, the pathological symptoms being confined to the areas immediately around the pustules.
Class **3**	The groups of pustules greatly enlarged and beginning to coalesce. The leaf has lost its vigour and there is marked general chlorosis over the areas of infection, due to the joining up of the chlorotic haloes around individual pustules.
Class **4**	Pustule groups now extensive, covering the entire surface of the leaf. The leaf assumes a striking rusted appearance. Extensive chlorosis precedes the death of the leaf.

* At the time of going to press, the design of a small air conditioned chamber has been completed and its construction is being directed through the Crown Agents.

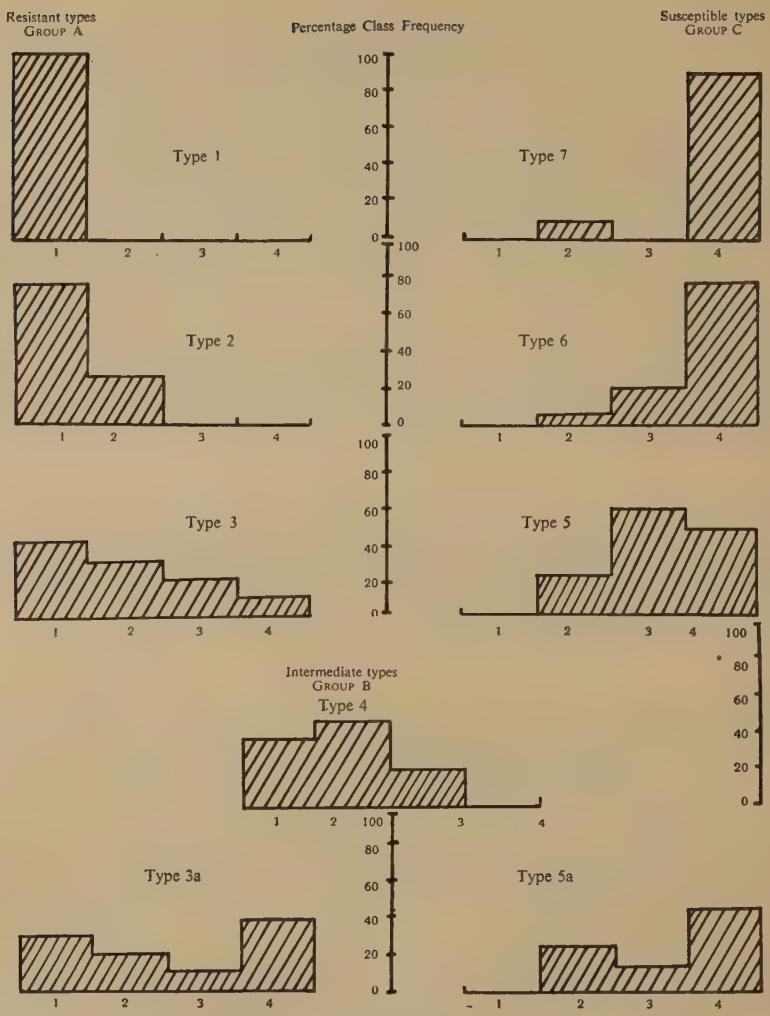

FIG. 1

A classification of maize varieties according to the class frequency of degrees of resistance* to *Puccinia polysora*.

* As measured by frequency of pustule formation. (Table 1)

This method of assessment was adopted as it was found easier for field assistants to follow and simpler than a strictly qualitative differentiation. The stages of the assessment key were chosen following observations made on the trend of the rust on plants in the field. These observations are referred to in the report. " Observations of *Puccinia polysora* in West Africa."

Varieties were assessed for rust susceptibility using a random sample of one hundred plants. The rust intensity was measured using a comparator-chart showing five degrees of rust intensity. Rust intensity was measured on the fifth leaf above the second node, and on the two successive leaves, at the mid-blade positions. The rust resistance of each variety was then recorded in terms of frequencies of plants in each of the rust assessment classes. (Fig. I.)

It was found that resistance ranged from that of varieties in which all the plants were classified as showing the highest proportion of class **1** of rust intensity—these were the most rust resistant varieties, to varieties in which all the plants were classified as showing the highest proportion of intensity class **4**—these were the rust susceptible varieties. In between these two extremes were varieties of greater heterogeneity, having a number of plants in two or more assessment classes.

From an inspection of the results expressed as frequency histograms for each of the varieties, it was found that these could all be placed in one or other of a total of nine types. Characteristic reactions of these types are illustrated by frequency histograms in Figure I. (Class **0** has been omitted as not being found in the field.) This figure shows examples of the analysis of the rust assessments to varieties in each of the nine types.

An analysis of the results of all the varieties so far assessed for rust resistance by this method is given in Table II (see overleaf). In this table, the varieties are grouped according to their rust reaction and their country of origin. A brief description is given in the table of the characteristics of each of the groups. Types 3a and 5a are so numbered because of their affinity to the mono-modal frequencies in group 3 and 5 respectively. It is believed that the representation of resistance by a single numerical value may lead to a false conclusion about a variety and that the method adopted provides a better picture of its behaviour with respect to the rust.

CONCLUSIONS

One result observed to date is that only seven varieties have been found where individuals show a frequency of rust intensity reaction normally distributed over the range (i.e. fall in Type 4 in Fig. 1). The majority are either classifiable as clearly resistant or susceptible. Types 3a and 5a have a bimodal distribution and may thus be considered intermediate between types 1 to 3, and 5 to 7 respectively.

The main feature of these results is therefore that the varieties may be classified geographically into ' New World ' varieties, bearing resistance to *Puccinia polysora*, and ' Old World ' varieties (Africa and Asia), in which resistance is absent (Stanton and Cammack 1953b). The distinction is not as marked as in natural populations, geographically isolated, since there have been recent imports of varieties from U.S.A. to parts of Africa, especially South Africa. This has tended to restore the identity between the two groups.

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TABLE II

RESULTS OF TESTS FOR RUST SUSCEPTIBILITY SHOWING MAIZE VARIETIES GROUPED ACCORDING TO HOST REACTION

(The name of the variety is followed by its acquisition number. See Appendix II) (Varieties in italics have been tested more than once.)

	GROUP A RESISTANT			GROUP B INTERMEDIATE			GROUP C SUSCEPTIBLE		
HOST REACTION (See Fig. 1) Country of Origin.	TYPE 1 More than 95% of the plants in the variety show resistance of the first degree.	TYPE 2 More than 75% but less than 95% of the plants show resistance of the first degree.	TYPE 3 Plants of the first degree of resistance are more frequent than plants of other degrees but constitute less than 75% of the total.	TYPE 3A Degrees of rust resistance Nos. 1 & 4 are more frequent than others. The frequency in a given population shows a bimodal distribution over the range.	TYPE 4 Plants of degree of resistance No. 2 are more frequent than others.	TYPE 5a Plants of degrees of resistance Nos. 2 and 4 are most frequent. Frequency shows a bimodal distribution over the range.	TYPE 5 Plants of degree of rust resistance No. 4 are more frequent than plants of other degrees but less than 75% of the total.	TYPE 6 More than 75% but less than 95% of the plants showing a degree of resistance No. 4.	TYPE 7 More than 95% of the plants showing a degree of resistance No. 4.
AMERICA CENTRAL AMERICA	*Mexican* 1 (83) Mexican 5 (87) Mexican 17 (99)	*Mexican* 3 (85) *Mexican* 7 (89) *Mexican* 14 (96) *Mexican* 16 (98) *Mexican* 20 (102) Mexican 21 (103) Mexican 22 (104)	*Cuba Amarillo* (117) La Creole Y.F. (Bot.) Mexican 4 (86) *Sicaragua* 40 Venezuela 1 (37)			*Mexican* 15 (97) *Mexican* 18 (100)			
U.S.A.		*N.C.* 1032 (18)		C. 50 (Bot.) Jellicourse (8) *Whatley Prolific* (9)	*White Tuxpan* (10)				N.C. 27 (17)
AFRICA SIERRA LEONE		Mende (166)						Sierra Leone 1 (77) Hooreliej (78) Marker (79) Sierra Leone 4 (80) Bakama (81) Sumbala (82)	Aku (164) Bulom
GOLD COAST					Sunyani (174)		Wenchi (173)	*Mankessim*	*Akwanga* and others *Bunsu* and others Kumasi (175)
NIGERIA									*Lagos White, Abakaliki White flour. Ibadan White flour. Ilorin White flour* and others
SOUTH AFRICA		Big Joe (14)	Tsolo (16) *Tsolo synthetic* (Bot.)				American White Flint (3)	Natal 8 Row (5) Dixie 18 (15)	Wisconsin White Dent (2) Cincinatti Bushman (4)
EAST AFRICA		*Kitale Flat White* (50) African grown maize (55)	Kenya (70) Kitale (76)		*Hickory King* (59) Kenya (66)	Common White maize (53) Kenya flat Yellow (65) Kenya Hybrid (68)	*Natal Horse Tooth* (56) *Kenya* (68) *Muratha* (52) *Mauritius* (136)	*Kenya* (64) *Korontari* (108)	
ASIA INDIA						*Kampur* (143) *White Velda* (124) *Red Velda* (125)	Pusa Yellow (144) *Arwhari* (127) *Duahmoger* (122) *Sarawah* (126)		
CEYLON					*Wellawaya* (129)		*Batticoloa* (133) *Embillipituya* (131) Maba-Oya (128) Pelwehera (138)	Hill (139)	
MALAYA						Malaya Red Flint (106)	Malaya Yellow Flint (107)		
AUSTRALIA									Improved Yellow Dent (48)

OBSERVATIONS ON *PUCCINIA POLYSORA* UNDERW. IN WEST AFRICA

R. H. CAMMACK

SUMMARY

1. Observations are recorded on a disease of maize caused by a short-cycled rust *Puccinia polysora* Underwood.
2. The rust first appeared on the African continent at Sierra Leone in 1949, and quickly spread eastwards and reached the islands of Mauritius and Reunion in the Indian Ocean in 1953.
3. All areas affected by rust have suffered economic losses.
4. A rust assay conducted during 1953 in Nigeria and the Gold Coast has shown that the rust is most intense in the coastal rain forest areas and less intense in the northern regions of the two Colonies.
5. Assay plots sited in Cameroons under British Trusteeship showed rust at 4,000 feet but not at 7,000 feet.
6. The yields of maize were affected by time of planting. Early crops gave high yields whereas those of later crops fell sharply.
7. With early plantings the time of onset of the rust was late and became earlier as the season progressed.
8. The spread of the rust on the host was rapid in early plantings and slower on later plantings.
9. The second rust of maize *Puccinia sorghi* Schw. is of general occurrence in West Africa but has never given rise to an epiphytotic.
10. The distributions of the two rusts of maize show *Puccinia polysora* to be mainly confined to the tropics, whereas *Puccinia sorghi* is most prevalent in temperate maize growing areas. This distinction is supported by the biological differences between the uredospores of the two rusts.

HISTORY OF THE EPIDEMIC*

I.—THE DISEASE

Observations on *Puccinia polysora* during 1952 and 1953 showed that it appeared only on the leaves and the leaf sheaths of the maize plant and not on the true stem, except at an advanced stage of infection when the rachis of the tassel was attacked. In April, 1954, it was observed growing on the stem of the maize plant for the first time. Uredo-sori were largest near the base of the stem.

* Most of the contents of this section are taken from Rhind (1952).

FIG. 2

THE SPREAD OF PUCCINIA POLYSORA.
IN AFRICA

Puccinia polysora was first described by Underwood in 1897 appearing on *Tripsacum laxum* in Alabama. It is cited as *Dicaeoma polysora* in Arth. Res. Sci. Congress Bot. Vienna 1906, 344. Later it was recorded on *Tripsacum lanceolatum*, *T. latifolium* and *Erianthus divaricatus*. Cummins (1941) first identified it on maize. He subsequently examined old herbarium specimens of maize rust and found that many records which had been identified as *Puccinia sorghi* Schw. were in fact *Puccinia polysora* Underw.

II.—THE APPEARANCE OF THE RUST IN WEST AFRICA AND ITS SUBSEQUENT SPREAD EASTWARDS

In 1949, a rust disease was reported at Sierra Leone by Deighton (1949). It was at first thought to be *Puccinia sorghi* but on re-examination proved to be *Puccinia polysora*. In 1950, the Gold Coast first recorded the disease in maize areas in the coastal rain forest belt. During that season the rust spread throughout the entire maize growing area, the south being most seriously affected with less severe damage in the central area. Also in 1950, the rust was observed in Dahomey and in South-West Nigeria where the disease was severe, attacking all local varieties. The following year rust appeared again in the south-western region of Nigeria but rapidly spread eastwards and northwards. The coastal rain forest belt suffered greatest damage and yields were very poor. It did not reach Kenya until 1952 where it was reported by Nattrass (1952). In Kenya, the epidemic was wide spread along the coastal area with some out-breaks around inland centres.

In 1953, the disease had spread south-east and was reported from Nyasaland, Northern Rhodesia, and from Lourenço Marques and Mozambique in Portuguese East Africa. A few months later it was observed in the islands of Mauritius and Reunion in the Indian Ocean. Within the space of five years, the rust had appeared in all territories in the central and south-eastern areas of Africa. Records of the appearance of the rust are shown in Table I (overleaf).

The progress of the disease is illustrated in Fig. 2.

THE SPREAD OF *PUCCINIA POLYSORA* UNDERW. IN AFRICA

(AFTER STANTON AND CAMMACK, 1953)

TABLE I

COUNTRY	WHEN FIRST REPORTED	SEVERITY	SPREAD
1. Sierra Leone ..	1949	Never severe	Generally distributed.
2. French Equatorial Africa	1949	Serious	Not indicated.
3. Belgian Congo ..	1949	Serious	Not indicated.
4. Senegal	1949	Not indicated..	Not indicated.
5. Cote d'Ivoire ..	1950	Severity depends on the amount of rain, humidity and earliness of sowing.	Generally distributed.
6. Gold Coast ..	1950	Very severe in coastal savannah.	Generally distributed.
7. Dahomey	1950	Serious. Second season maize less severely attacked,	Very serious, especially in the south.
8. Nigeria	1950	Severe in the South West ..	Confined to Southern Nigeria.
9. Kenya	October, 1952	Severe on the coast	Mostly coastal areas with some around inland towns.
10. Tanganyika ..	October, 1952	Severe in parts	Over wide area.
11. Nyasaland ..	March, 1953	Not indicated..	Over wide area.
12. Rhodesia	April, 1953	Not indicated..	Over scattered areas.
13. Lourenço Marques	May, 1953	Reported as heavily attacking maize.	Middle region.
14. Mauritius	June, 1953	Reported as destructive outbreak.	Not indicated probably over the whole island.
15. Reunion (near Mauritius)	June, 1953	Not indicated..	Not indicated.

III.—THE ECONOMIC EFFECT OF THE EPIDEMIC

The severity of the disease in West African territories has caused heavy losses in maize yields. In 1949, no exact figures were obtained for Sierra Leone but it is considered that the losses were much less than those experienced later in other territories.

Meiffren (1950) states that the maize growing areas of Pobé and Allada in Dahomey were badly attacked in 1950. The disease was at its peak from May to September and resulted in a local food shortage which caused the price of maize to rise 500%. Severe losses were also recorded in the Ivory Coast.

In Gold Coast, the disease first appeared in the Colony and Ashanti regions in May, 1950, and later that year in the Trans-Volta region. April sown maize was severely attacked at the flowering stage and losses up to 50% were reported. Rust was also observed in the northern maize growing areas of Gold Coast but not to the same extent as in the wetter southern districts. In 1951, the disease again appeared in April, in the south-west corner of Gold Coast not reaching the Ashanti region until May of that year.

It is significant that farmers in Togoland and Trans-Volta planted cow-peas and groundnuts in preference to maize. In 1951, early sowings in Gold Coast showed less severe damage than later plantings which had losses of 40% in the middle belt and in the region of 60% in the south-west. Losses in 1951 were less on the average than those of 1950.

In Nigeria, the epidemic during 1950 was severe and present throughout the whole coastal belt. Losses were estimated at approximately 40% and in 1951 nearer 50%. Losses declined again in 1952 and 1953. At no time, however, were losses in yield in Nigeria as high as those in Gold Coast. The Agricultural Department of Nigeria and Gold Coast, urged the farmers to plant as early as the onset of the rains would allow. Where this measure was adopted yields were invariably better. Figures for the estimated losses in yield were obtained by the various Departments of Agriculture from maize grown at the experimental stations.

THE RUST INTENSITY ASSAY CONDUCTED OVER MAIZE GROWING AREAS IN NIGERIA AND GOLD COAST DURING 1953

Outline of the experiments

Casual reports of *Puccinia polysora* in West Africa referred to in the introduction gave a general indication of the extent of the disease. With the object of gaining more precise information, rust assay plots were laid out in Nigeria and Gold Coast. These plots also provided information on the amount of rust occurring in different areas and augmented observations made in farms and experimental stations throughout the areas covered by the assay. With the co-operation of the Department of Agriculture, Dahomey, it was possible to site one assay plot at Niaouli, thus completing the link between Nigeria and Gold Coast.

Each assay plot was 1/10th of an acre and consisted of one row each of six varieties separated by ' spreader lines ' of the highly susceptible variety of maize, Lagos White. The six test varieties were chosen, after field tests at Ibadan, as being representative of the full range of rust susceptibility. A quantitative scale representing five degrees of rust intensity (0—4) was used to assess the incidence of rust on the assay plots. This key was similar to quantitative

keys used for other cereal rusts. To minimize observational errors, provision was made to enable the assistant to compare the assessment key directly with the infected leaves. This was done by using a card with 2 in. square windows. The scale of rust intensity could be slid past one window, the second window being placed directly over the maize leaf. It was found that this method reduced personal differences in observation.

The third, fourth and fifth leaves above the second stem node of the maize plant were used for assessment. Those leaves were chosen after extensive trials principally because they were retained throughout the life of the maize plant and gave a highly representative picture of the development of the rust on the host. Using the second stem node as a marker made it easy for assistants to assess the correct leaves. To avoid any possibility of error in this connection, the third leaf above the second stem node was marked with a tag label tied round the leaf sheath. The mid-regions of the fifth, sixth and seventh leaves of every plant in each row were assessed in this manner 30, 50, 70 and 85 days after germination. The first assessment date represented the 5th—6th leaf stage, the second tasselling, the third the milk ripe stage and the last maturity. Those assessment times were chosen since it was found that during the main growing seasons rust never appeared before the 30th day, and further, between the tasselling and milk ripe stages, the incidence of rust was critical to the plant. There were twenty-five maize rust assay plots distributed as shown in Table II.

TABLE II

The relationship between vegetation zones and the incidence of maize rust

Territory and Vegetation Type	Rust intensity		
	Plot mean	Zone mean	Time of planting in days after the 10th of April
NIGERIA			
(*a*) **Sudan Savannah**			
(i) Maiduguri	0·0	0·5	81
(ii) Daura	1·0		58
(*b*) **Guinea Savannah**			
(i) Samaru	1·6	1·6	50
(*c*) **Relic rain forest**			
(i) Yandev	0·5		35
(ii) Abakaliki	2·7		20
(iii) Auchi	0·9	1·6	2
(iv) Nkwelle	2·4		25
(*d*) **Rain Forest**			
(i) Abak	2·9		8
(ii) Umudike	1·0		0
(iii) Ogba	1·6	2·8	10
(iv) Agege	4·0		16
(v) Ipokia	4·0		17
(vi) Ibadan	3·0		15
(vii) Efferun	2·7		
DAHOMEY			
(*a*) **Rain forest**			
(i) Naiouli	3·5	3·5	?
GOLD COAST			
(*a*) **Guinea Savannah**			
(i) Wenchi	1·0	1·0	8
(*b*) **Coastal Savannah**			
(i) Pokoase	1·7		0
(ii) Mankessim	4·0	2·9	26
(*c*) **Relic rain forest**			
(i) Kpeve	1·6	1·6	4
(*d*) **Rain forest**			
(i) Mampong	2·5		6
(ii) Sunyani	3·5		8
(iii) Aiyinasi	3·3		14
(iv) Bunsu	3·1	3·2	18
(v) Kumasi	3·5		18
(vi) Esiama	3·5		20

FIG. 3

RELATIVE RUST INTENSITIES IN NIGERIA AND GOLD COAST.

The average of the four assessments was determined in order to obtain the mean intensity for each plot (Table II, column 3). Since the number of plots varied from 1 to 7, the mean rust intensity for each zone was obtained by calculating the average of the relevant plot means (Table II, column 4).

The relationship between the incidence of maize rust and local climatic and environmental conditions

Table II shows that the rust was most intense in the coastal rain forest areas and decreased in intensity towards the north. In Nigeria, the rust value was 0·5 in the Sudan Savannah, 1·6 in the Guinea Savannah and Relic Rain Forest areas, and 2·8 in the Coastal Rain Forest. In the Gold Coast, the rust increased from a value of 1·6 in the Guinea Savannah to 3·2 in the Coastal Rain Forest areas.

The rust values were compared with each climatic factor and it became evident that rust intensity was in general related to rainfall and humidity more than to the incidence of the other climatic factors. The vegetation zones are an expression of all climatic and environment factors in any one area and it is the combined effect of all those factors which appears to affect the rust intensity.

The effect of time of planting on rust intensity was very noticeable. An attempt was made to plant all the plots at the same time but this proved impossible due to the wide variation in the time of onset of the rains and other problems of husbandry. Irrespective of their position, assay plots planted late showed considerably more rust than those planted earlier. A striking example of this is shown in the two assay plots sited in the Coastal Savannah zone of the Gold Coast. Pokoase was planted on the 10th of April and gave a mean rust value of 1·7. Mankessim was planted 26 days later and gave the maximum rust intensity of 4·0. In the example quoted, the two plots were assessed by the same observer. Variations in planting date introduced a large error into the rust assay.

The effect of time of planting on the incidence of rust is discussed in the next section and the reason for the increase with late plantings may be due to the rise in the amount of potential, airborne inoculum as the growing season progresses. Another factor which must be taken into consideration is that in the northern areas of Nigeria and Gold Coast very little maize is grown and consequently the density of uredospores in the atmosphere may be much less than in the southern coastal areas. The assay plot data has been interpolated and corrected for time of planting to give the distribution pattern of rust intensity shown in Figure 3.

The altitude barrier

Two plots were sited at Bamenda, Cameroons, under British Trusteeship. The altitudes of the two plots were 4,000 and 7,000 feet respectively. On the lower plot both rusts of maize were present, infected leaves showing approximately ten times as much *P. sorghi* as *P. polysora*. The sori of the two rusts were mixed on the surfaces of the leaves, but were distinct and never confluent. The plot at 7,000 feet was infected with *P. sorghi* only and it may be that the altitude barrier to the growth of *P. polysora* lies within the range 4,000—7,000 ft.

THE BEHAVIOUR OF THE RUST IN RELATION TO THE TIME OF PLANTING OF THE HOST

During 1953 and the beginning of 1954, maize plots were laid out at 10-day intervals to examine the effects of the different seasons on the incidence of rust on the host. The plots were 1/40th of an acre and planted with a highly susceptible local maize—Lagos White. Uniform dressings of fertilizer were applied before each planting. One hundred plants from each plot were selected at random and the 5th, 6th and 7th leaves assessed quantitatively for rust every week.

Three factors changed markedly during the year.

(*a*) The yield of maize in pounds per acre.

(*b*) The time of onset of the rust on the host after germination.

(*c*) The rate of spread of the rust on the host after onset.

The effect of time of planting on yield. (Fig. 4.)

Each of the sequential plots was harvested 12 weeks after planting and the dry grain weights determined. In Figure 3 the time of planting has been plotted against the subsequent yield of the plot at harvest. The time from planting to harvest may be taken approximately as three divisions on the abscissa. The yields in lbs. per acre fell rapidly with successive plantings from 1,100 lbs. in plots planted early in April to 600 lbs. in those planted in June. Thereafter the yield rose steadily, even through the dry season months of December to March. In March 1954, 1,300 lbs. per acre were obtained.

The relation between time of planting and the time of onset of the rust on the host (Fig. 5).

The weekly rust assessments on each of the sequential plots enabled the observers to determine the time at which the rust appeared on the host after planting. The first of the series of plots was planted on the 23rd of March, 1953, and rust appeared when the plants were seven weeks old. The time of rust onset became earlier with successive plantings until in July the plants became infected when they were three weeks old. This is illustrated in Fig. 6 (solid line). Time of onset is expressed as the number of weeks after planting of the appearance of the first pustule on the plant irrespective of the leaf on which it appears. Thereafter the time of onset again began to get later until in November it was appearing once more during the 7th week of growth, at which it stayed throughout the dry months until March.

The effect of time of planting on the rate of spread of rust on the host.*

On each plot, after the rust had appeared, the rate of spread was observed by weekly assessments of the 5th, 6th and 7th leaves. These leaves are present throughout the life of the plant and changes in the amount of rust with time can be noted. A curve of increase of rust intensity with time was constructed for each plot and the tangent of the angle of incidence of this curve taken as measure of the spread of the rust on the host. The resultant relationship, viz. change of rate of spread (tangent of angle of the sigmoid developmental curve of rust on each plot) against time of planting is shown by the dotted line in Figure 6.

As with the time of onset the rate of spread decreased rapidly from April until July, and thereafter increased uniformly each month until the dry season.

* Rate of spread of foliicolous fungi in relation to rate of growth of the host is discussed by Last (1953). Work is continuing on this phenomenon and will be reported subsequently.

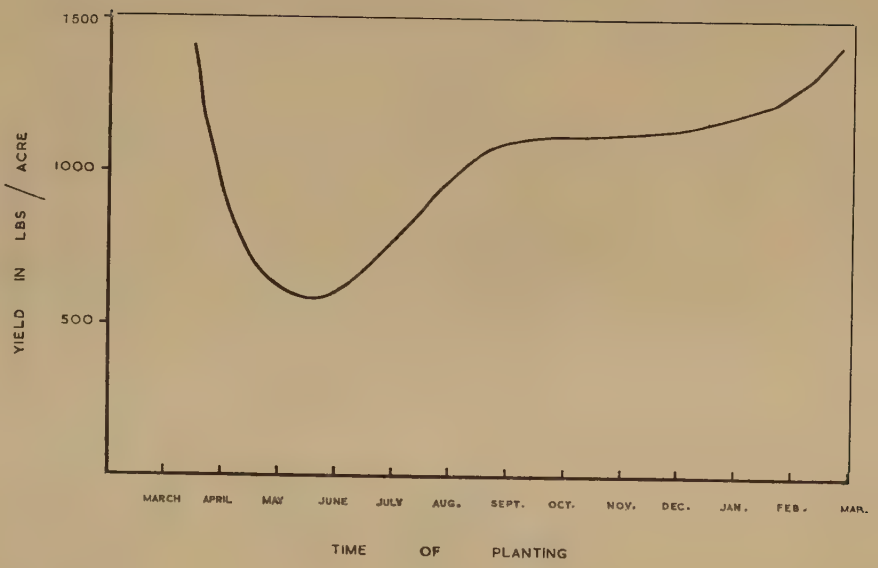

FIG. 4

THE VARIATION IN YIELD OF A RUST SUSCEPTIBLE VARIETY OF MAIZE WITH TIME OF PLANTING.

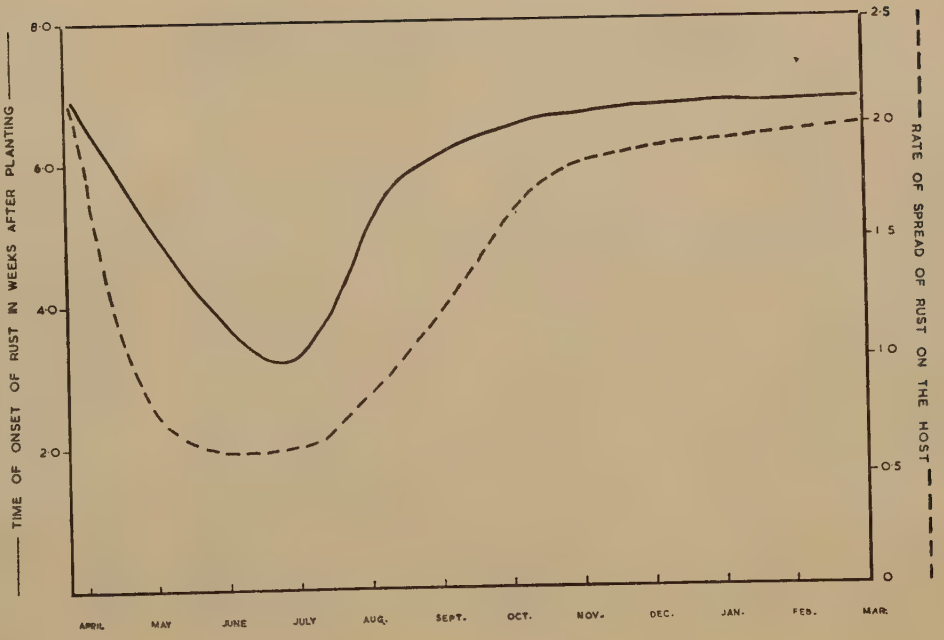

FIG. 5

THE VARIATION IN TIME OF ONSET AND RATE OF SPREAD OF RUST ON A SUSCEPTIBLE VARIETY OF MAIZE WITH TIME OF PLANTING.

TABLE III

The effect of planting date on yields of maize and on the incidence of rust

	Onset time after germination (weeks)	Rate of spread (see text)	Yield (lbs. per acre)
April 1953	7	2·2	1100
May	5	0·6	650
June	3–4	0·5	600
July	3	0·5	750
August	5	0·7	900
September	6	1·2	1070
October	6–7	1·6	1090
November	7	1·8	1100
December	7	1·8	1190
January 1954	7	1·9	1220
February	7	1·9	1240
March	7	2·0	1300

POSSIBLE FACTORS AFFECTING YIELD

Maize planted at the beginning of the main growing season (February to early April), gave high yields. It was also found that in those early plantings the time of onset of the rust was late—not until the seventh week. By the seventh week the vegetative growth of the host had practically stopped and the plants had entered into the reproductive phase. The late onset resulted in the vegetative growth of the plants being unaffected by the rust and also the developing cobs were fertilized before the rust intensity reached a destructive level.

In mid-season plantings, i.e. May to July, the rust onset occurred at an early stage of growth of the host. The leaves of the maize were infected while still young, and partly killed, and the plants at maturity were stunted. This set-back in the vegetative phase retarded the development of the ears. The emerging silks lost their turgor and became shrivelled. This seriously affected pollination and may have been caused by an increase in water loss due to the extensive disruption of the surfaces of the leaves by the rust.

Other factors which must be taken into consideration are :—

(*a*) *Seasonal changes in the atmospheric uredospore content.* Preliminary work with the Hirst Volumetric Spore Trap (Hirst 1952) at Moor Plantation, Ibadan, has shown that the uredospore content of the atmosphere increased rapidly from March onwards and by the end of May, the number of airborne uredospores had increased 120 times. This rise in the amount of potential inoculum may have been partly responsible for the earlier time of onset during the months of June to October.

(*b*) *The effect of reduced host vigour on the development of rust.* Plantings made in the mid-season months of May to August gave less vigorous plants than those planted at the beginning of the main maize seasons. This loss in vigour may have been due to several factors and it may contribute to the reduction in the rate of spread of the rust on the host.

Experiments are in progress to determine the effects of host vigour, and nutrition, on the development of the rust.

THE SECOND RUST OF MAIZE, *PUCCINIA SORGHI* SCHW.

The occurrence of Puccinia sorghi

Puccinia sorghi Schw. has been reported many times from most of the maize growing areas of the world. It is more cosmopolitan than *Puccinia polysora*, the latter being confined mainly to the tropics. In West Africa, it has been reported from Sierra Leone by Deighton (1944), in Gold Coast by Bunting (1926). At the beginning of 1953, three records were established from the middle and southern belts of Nigeria by Stanton and Cammack (1953). It was also found to be generally distributed throughout maize growing areas in British Cameroons. This rust is therefore of general occurrence throughout West Africa but no records of any serious outbreaks have been recorded.

At one time, considerable confusion existed in the differentiation of the two rusts of maize. Examination of herbarium materials has proved, however, that *Puccinia polysora* was not observed in West Africa prior to 1949, when it was recorded by Deighton (1949) in Sierra Leone. Whereas no specimens of *Puccinia sorghi* collected since 1949 have proved to be *Puccinia polysora*, none of the specimens prior to that date have shown the latter rust.

The main differences between the two rusts are shown in Table IV.

TABLE IV

A comparison of the two rusts of maize occurring in West Africa

Puccinia polysora Underw.	*Puccinia sorghi* Schw.
1. Uredosori. Pustules small and circular becoming densely and uniformly distributed, cinnamon to yellowish brown. Commonly opening by a longitudinal slit.	Amphigenous, scattered, pulverulent, cinnamon brown.
2. Uredospores. Yellowish or golden, ellipsoid or oval, 29—37 (40)μ × 21—29μ, finely and sparsely echinulate, pores, usually 5, equatorial.	Broadly ellipsoid or globoid, 26—32μ × 23—29μ, wall cinnamon brown 1·5—2μ thick moderately echinulate, pores 4, sometimes 3, approximately equatorial.
3. Teleutosori. Subepidermal, indehiscent, 0·5—1·5 mm long, chocolate brown.	Amphigenous, usually scattered, oblong, soon exposing the spores.
4. Teleutospores. Usually angular from pressure, chestnut brown, 29—41μ × 19—27μ, wall 1·5μ, usually not much thickened above, pedicel short ; mesopores common.	Oblong or ellipsoid, 29—45μ × 16—23μ rounded or obtuse both at apex and base, slightly constricted at the septum, wall dark chestnut brown, 1—2μ at the sides, 5—7μ above pedicel once or twice length of spore.
5. Hosts. (*a*) II and III stages *Zea mays*, etc. (*b*) 0 and I stages unknown.	*Zea mays* rarely *Euchlaena mexicana*. *Oxalis* spp. Determined by Arthur (1904).

II.—The different distributions of the two rusts

The different distributions of the two rusts, and the reason why *Puccinia sorghi* has never reached epiphytotic proportions in West Africa, may be explained in part by biological differences between the uredospores of the two rusts listed in Table V.

TABLE V

A comparison of the biological differences of the uredospores of the two rusts of maize occurring in West Africa

*PUCCINIA POLYSORA**	*PUCCINIA SORGHI*
1. Temperature range for uredospore germination 9·5—34°C. Optimum Temperature for germination 27°C.	(Weber, 1922). 4—30°C. (Weber, 1922). 17°C.
2. The percentage uredospore germination under different humidities at 25°C. :	(Smith, 1926)
% R.H. / % germination	% R.H. / % germination
100 / 90—95	100 / 54
98·00 / 80—87	99·5 / 46
97·50 / 1—4	99·1 / 36
92·48 / 0	98·7 / 25
	97·5 / 3
3. Viability of uredospores : (*a*) In the field 27—50 days. (*b*) In the laboratory at 25°C. and 50% R.H. 36—48 days.	Not determined under tropical conditions.

* Results obtained at Moor Plantation, Ibadan, by the West African Maize Rust Research Unit.

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FACTORS AFFECTING THE YIELD OF MAIZE IN WEST AFRICA

W. R. STANTON

This paper considers the relative importance of different properties of the plant which may be used in the improvement of maize yield in West Africa by breeding.

Introduction

Maize is an important part of the staple diet in all the West African territories, particularly in the High Forest, Secondary Forest and Guinea Savannah zones. It is supplementary in importance to Cassava, *Manihot utilisima*, and yams, *Dioscorea sp.* [1, 2, 3]. The manner in which it is used varies according to local custom. It is almost entirely used for human consumption either as a vegetable in the immature state or as a hand-ground meal. The general preference has been in the past for the ' flour ' maizes, although, in areas where it is used as a vegetable, yellow dents are also grown.

A detailed survey of the maize types of West Africa has not yet been made, but the range of types has been demonstrated by samples received from different regions via the Departments of Agriculture. Heterogeneous mixtures containing purple, and red coloured maizes are occasionally found but the white flour and dent types predominate. The maturity range extends from 60 to 110 days. This range is not comparable with that of the varieties from temperate zones. It is found that maizes imported from such zones tend to have their maturity time shortened by as much as 30 days. It is possible that the maturity range may be extended by importation of late maturing types from the Caribbean areas. The West African maizes are moderately resistant to a wide range of pests and diseases, whereas imports of materials from the North American Maize Belt and South Africa usually succumb to one of these. An increased range of variability in this direction is apparently possible from our observations on imported tropical lines.

By alteration of the present maize varieties it is possible to produce greatly increased yields and further increases are possible by the incorporation of heterosis, changes in agronomy, the use of fertilizers and plant protection methods. This paper is confined to a consideration of the various changes in genotype which are likely to affect yield. These changes may be divided into those giving better adaptation to (*a*) the climatical and edaphical environments (*b*) the biological environment.

Climate

The climate of the southern belt of the West African territories has a relatively steady temperature through the year, a long sporadic rainy season with a variable gap in the middle and a dry season which increases in length and intensity towards the North of the territories. Severe storms are experienced at the beginning and end of the rainy season. Relative humidities are high at all times of the year at night and this high humidity continues well into the morning during the rainy season. This phenomenon has an important bearing on plant infection and spore dispersal. It also affects the phasic development of numerous insect species. In Table 1, p. 38, the rainfall and relative humidity at Ibadan (Secondary Forest Zone) for a typical year are given.

Soil

The nitrate status of the soil at the beginning of the rainy season has an important bearing on the maize crop. Extreme fluctuations in this nutrient occur. The concentration reaches a sharp peak early in the rainy season and little is detectable in the soil during the remainder of the year. This peak has a marked influence on disease attack. Much work has yet to be done, however, on the levels and changes in the nutrient status in West African soils. Nutrient deficiencies are partly attributable to low base exchange capacities owing to the low level of the appropriate clay minerals. The rapid destruction of all organic material contributes to this low base exchange capacity and the water retaining capacity is also low. These factors favour the attack of fungal pathogens and pests which require impoverished or moribund plant tissue or incipient wilting of the plant. Obligate parasites which are favoured by adequate nutrition of the host are thus at a disadvantage.

Biotic Factors

As previously mentioned, maize is mainly grown in the High Forest and Secondary Forest zones. The actual vegetation differs especially in Nigeria, from the natural climax (due to over population) vegetation so that in the Eastern Region, for instance, maize is often grown in Derived Savannah areas. In the High Forest maize is grown in clearings. There is a moderately dense canopy overhead and partial etiolation of the plant occurs. In the Savannah Zones the weed problem is serious in that the maize must compete with a dense grass mat, which is not destroyed by the primitive methods of cultivation. The forest zone provides protection from wind damage though not from torrential rain.

The larger fauna probably affect maize yields more than they do those of any of the other staple crops. The commonest pest is the bush-fowl (*Francolinus bicalaratus bicalaratus*) which removes the seed at planting time (local maizes are characterized by a rapid rate of germination relative to that of many lines that we have imported and tested to date. It may be that selection has occurred for factors favouring rapid germination). At a later stage, " cutting-grass " (*Thryonomys swinderianus*) gnaw the stems for the sake of the sugary sap. The mature maize is subject to elephant and monkey damage (particularly *Papio anubis*). The latter was observed attacking experimental plots in the Guinea Savannah zone (preference being shown for the large eared soft grained lines). Imported maizes in which the ear is borne near the ground have been severely damaged by bush-fowl and various rodents in Ibadan trials. It appears essential that the ear should be carried three feet above ground level for this reason.

Husbandry

Husbandry methods have an important bearing on pest and disease attack. The forest is cut during the dry season leaving only the larger trees. The debris after drying is burned. Thus, the clearings consist of patches of wood ashes with fallen partly burned trunks and some trees still standing. The first crop from this is usually comparatively free from weeds owing to a complete change from high or secondary forest flora to open woodland flora, the forest having been regenerating for ten years or more before clearing. At the time of the second crop, regeneration of some of the trees has occurred. The weed population is greatly increased. The soil has changed in humus content and the nutrient level has been affected by leaching.

Time of planting

Planting is normally done in the main maize areas at the beginning of the rains and again after the break in early August. As the northern limit of maize growing is approached, the planting is confined to one main season crop and in the high forest areas, with an incipient dry season, maize may be planted at almost any time. River beds and swamp areas are used for growing maize in the dry season so that small plots may be found on the banks of streams right through the savannah area.

Inter-cropping

In the main maize belts (Ilaro division in Abeokuta province, Ijebu province and southern Ondo province in Nigeria ; South Dahomey ; the Colony in the Gold Coast) large areas of sole-crop maize are to be found. In the Eastern Region, Nigeria, the maize is commonly grown on the sides of yam heaps. In Bamenda, Cameroons, above the forest level, extensive areas of maize occur as a sole crop. A common mixed cropping system in Western Nigeria is maize with cow peas (*Vigna catiang*) or other beans. The dead maize stem is then left as a support for the vine of the bean.

Seed saving and storage

A final factor of importance in considering the breeding problem is the storage and marketing of the grain. A farmer frequently does not save his own seed but buys it from the market to replant his next crop. Within the area served by one market, there is therefore a frequent redistribution of the maize population. There are no equivalent practices to those of the American Indians, Aztecs and other Central American tribes, designed to conserve a particular variety or type of maize. The maintenance of purity of types is fortuitous. The term ' variety ' itself is therefore misleading. It may be said that there are clines in the population from one area to another and marked changes in varieties only occur where there is the barrier of an uncultivated area or some natural or ethnological obstacle.

Summarizing the situation

From the brief survey given above it is clear that maize growing is in a very primitive stage of development in West Africa and that improvements may be effected in a number of directions. However, limitations are set on the type of improvements firstly, by the capacity of the farmer to maintain improved types and secondly, by the future changes in agronomic practice in the different areas. For instance, it does not appear at the moment that intensive mechanisation or the application of fertilizers at high levels are likely to be part of the husbandry for many years. It is, however, possible that mechanical milling, as is already practised for rice, will permit the use of grain of optimum yielding capacity irrespective of type (i.e. hardness). Improvements in storage conditions may lessen the importance of selection for increased weevil resistance. In the following figure (Fig. 7), a preliminary analysis has been made of some of the factors affecting the yield of varieties grown in replicated trials at Ibadan during 1953. The value of these results is limited by their being for the period of one year only. The figures used, have been the varietal means (expressed for convenience in terms of 100's of lbs. per acre) taken from replicated trials covering a range of local West African varieties, imported varieties from North and South America and other parts of Africa.

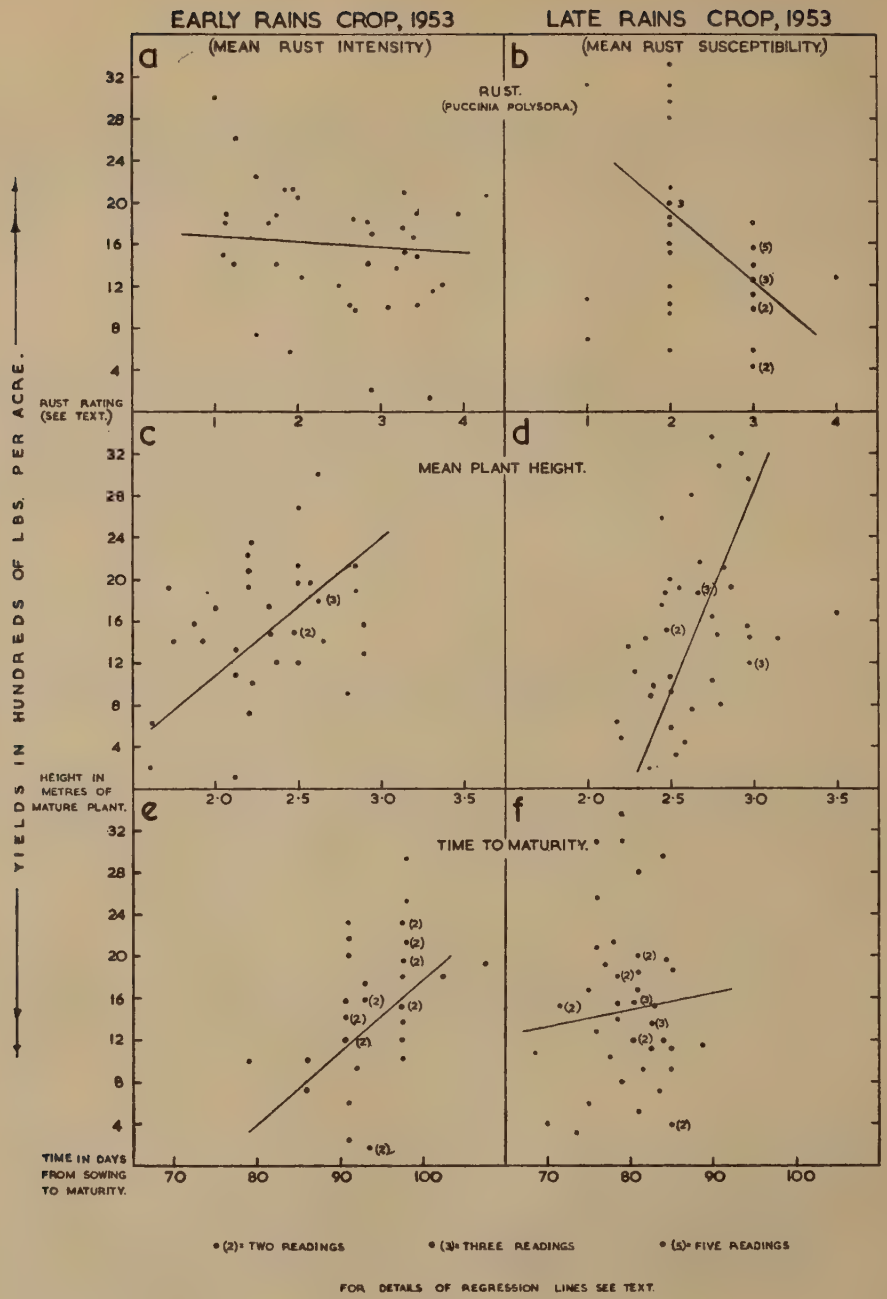

FIG. 7

VARIETAL VARIATION IN RUST SUSCEPTIBILITY, MEAN PLANT HEIGHT AND TIME TO MATURITY SHOWING THE EFFECT ON YIELD.

The " early rains " varieties were all sown during the last week in March and the " late rains " group were sown during the third week in August. At Ibadan, the rainy season, from mid-March to early November, is divisible into two sub-seasons by a dry period in early August. The varieties used for the first and second season data are not identical, there being a group of hybrids included in the second season data which was not grown in the first season. Also, some of the first season varieties were absent from the second season trials.

Each graph represents the scatter of varietal means with respect to an independent variable. The standard error of estimation of each point is approximately 4·0 (100's lbs. p.a.) for the first season data and 2·3 (100's lbs. p.a.) for the second season data. Linear regressions have been fitted to show the influence of the independent variable on yield. Further analysis was not justified from the existing figures although the form of the relationships is discussed for each graph.

Rust Resistance (*Fig. 7a & b.*)

Methods of assessment of rust resistance have been described earlier in this report and for this character there is not complete correspondence between the first and second season data. The first season data was confined to a quantitative estimate relating the numbers of pustules on different varieties under uniform conditions of infection. Until we were familiar with the material it was felt that a qualitative classification might show greater bias than a quantitative one. For the second season the qualitative mean varietal assessment was used. This latter estimate has given an exaggerated correlation of the effect of rust susceptibility on yield owing to the few values in the lowest and highest categories. The first season estimate is not significant owing to the wide scatter of the points. From an inspection of the second season data (*b*) it would appear that the mean difference in yield between a variety which is lightly and heavily attacked may be of the order of 800 lbs. per acre, i.e. a 40% drop in yield from the lightly attacked variety. This relationship is being further investigated. It would appear that the correlation between rust and yield is greatest over the range " medium to high intensity/susceptibility."

Plant height (*Fig. 7c & d.*)

The mean plant height was based on 400 measurements per variety and the linear regression for both first and second season data are significant. Although the fit is good, it will be possible with more data to fit a regression curve having a maximum value. From existing data it appears that this value lies between the optimum heights of 2·6 and 2·8 metres, being shorter for first season crops. The figure is relatively high compared with temperate zone maizes and it is likely that the optimum will vary over the different ecological zones, taller maizes being required in the " High Forest " zone.

Time to maturity (*Fig. 7e & f.*)

Time to maturity was taken as time from plantings to full starch formation in the grains. A number of factors tend to advance the maturity of the plant. In the first season rust appears to be the main factor, and an optimum figure will be difficult to obtain until the population used in estimating this optimum is relatively rust resistant. In comparing these figures (i.e. l.f) with maturity times of temperate zone maizes, it must be remembered that the maturity dates tend to be advanced under West African conditions in proportion to their lateness.

Thus maizes from the U.S.A. listed as being of 140-day-maturity mature in between 105 and 110 days, whereas 90-day maize are only advanced to 80-days maturity. From a comparison of the two distributions, it would appear that a later maturing maize is required in the first season than the second. Very late maturing maizes in the second season are prevented from developing properly by the onset of the dry season. Considering the results for plant height, the linear regression is only an approximation and fails to reach significance in the second season data. This data was further analysed by removing a group of hybrids (12 of the 45 points on the diagram) and calculating the regression on these and the remainder separately. These hybrids tended to be past the optimum and separately they gave a negative regression (Table 2 f.ii). Summarizing these observations it is tentatively suggested that the values of 95 and 80 days are estimates of the maturity times likely to be found suitable for first and second season varieties respectively with adjustments for the savannah and high forest zones.

In addition to the correlations illustrated, investigations have been started on the effect of stem borer infestation. This is a complex infestation of a number of species particularly *Busseola* and *Sesamia* species. Infestation was estimated by the number of plants " snapped off ". Analysis of the variance of the linear regression showed that the effect of borers was not significant. The value approached significance sufficiently to justify further investigation and indicated a loss of 20% of the crop with 10% snapped-off plants (the difference being due to " snapped-off plants " being an underestimate of the total damage).

In conclusion, it is clear that the partial regression of a number of variables on yield is likely to show significance by appropriate experimentation and that the investigation of these will provide valuable guidance in the search for varieties optimal for West African conditions. These observations are being extended to a number of centres in Nigeria and the Gold Coast in the coming year (1954).

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TABLE 1

RAINFALL, TEMPERATURE AND HUMIDITY AT IBADAN, NIGERIA, 1953

January—March

	R.F.	Mean Max.	Mean Min.	Mean Dry	Mean Wet	R.H.
January ..	0·00	89·5	70·4	87·5	76·8	62·0
February ..	0·93	90·7	71·9	87·5	74	7·76
March ..	2·50	91·6	72·3	80·8	76·6	82·2
	TOTAL 3·43	90·6	71·5	85·3	75·8	73·9 Mean Average

April—June

April ..	3·47	92·5	72·2	82·2	77·9	81·7
May.. ..	8·59	88·7	71·6	79·9	75·9	83·1
June.. ..	6·14	85·2	70·6	77·5	74·8	88·2
	TOTAL 18·20	88·8	71·4	79·9	76·2	84·3 Mean Average

July—September

July ..	3·36	82·6	70·8	75·7	73·3	88·6
August ..	1·00	81·1	69·4	73·8	71·5	89·4
September ..	6·65	83·9	71	75·9	73·5	89·0
	TOTAL 11·01	82·5	70·4	75·1	72·8	88·6 Mean Average

October—December

October ..	6·00	86·2	70·7	77·6	74·5	86·4
November ..	2·36	90·5	71·1	86·3	77·2	91·9
December ..	0·21	89·3	70·4	87·3	76·8	62·0
	TOTAL 8·57	88·6	70·7	83·7	76·2	80·1 Mean Average

R.F. = Rainfall. Total for year 42·21 ins.
Mean Max. = Mean maximum temperature.
Mean Min. = Mean minimum temperature.
Mean Dry = Mean dry bulb reading.
Mean Wet = Mean wet bulb reading.
R.H. = Relative Humidity %.

TABLE 2

Significance of regression lines illustrated in Figure 1.

Graph No. (Fig. 7) Title	Mean Yield (y) (as 100's of lbs. p.a.)	Mean Value Independent variable (x)	Regression coefft. y on x	Analysis of Variance					
				Item	D.F.	S. Squares	Variance *Vxy/e* Ratio	V.R. Regd. 5% 1%	
(a) Yield in relation to rust intensity. 1st Season 1953.	15·50	2·36 Units of intensity	−0·027	Cov. y on x Error (e) Total y	1 34 35	0·24 1298·45 1298·69	·0063	4·17 7·56	Not Sig.
(b) Yield in relation to rust susceptibility. 2nd Season 1953	15·54	2·42 (on susceptibility scale)	−14·40	Cov. y on x Error (e) Total y	1 34 35	985·25 1058·72 2043·97	31·64	4·17 7·56	Sig.
(c) Yield in relation to the mean height of the variety. 1st Season 1953.	14·97	2·30 (metres)	13·40	Cov. y on x Error (e) Total y	1 35 36	1075·19 414·81 1490·00	9·69	4·17 7·56	Sig.
(d) Yield in relation to the mean height of the variety. 2nd Season 1953	15·20	2·65 (metres)	9·38	Cov. y on x Error (e) Total y	1 43 44	262·07 2151·06 2234·32	5·24	2·84 7·31	Sig.
(e) Yield in relation to time of maturity. 1st Season 1953.	15·43	96·72 (days to maturity)	0·73	Cov. y on x Error (e) Total y	1 30 31	176·17 1102·58 1278·75	4·79	4·17 7·56	Sig.
(f) Yield in relation to time of maturity. 2nd Season 1953. Varieties.	12·32	81·67	0·25	Cov. y on x Error (e) Total y	1 31 32	45·00 629·91 674·91	2·22	4·17 7·56	Not Sig.
(fii) Do. Hybrids.	23·66	81·67	− 1·06	Cov. y on x Error (e) Total y	1 10 11	75·08 419·08 494·17	1·79	4·96 10·04	Not Sig.
(fiii) Do. (Regression line fitted to scatter diagram.) Total	15·34	81·67	+ 0·14	Cov. y on x Error (e) Total y	1 43 44	14·85 2287·56 2302·41	0·28	4·08 7·31	Not Sig.

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14. The Crown Agents for Oversea Governments and Administrations.

APPENDIX I

Staff as at 31st of December, 1953

SENIOR STAFF

1. W. R. Stanton, B.Sc. (*Readg.*), Ph.D. (*Lond.*)
   Senior Scientific Officer (Genetics).

2. R. H. Cammack, B.Sc., Hons. (*St. Andrews*)
   Scientific Officer (Mycology).

JUNIOR STAFF

3. T. A. Udom, Agricultural Assistant Grade III.
4. A. A. Ononokpono, Agricultural Assistant Grade III.
5. Miss L. I. Orumbie, Agricultural Assistant Grade III.
6. I. O. Adebiyi, Clerical Assistant.
7. M. A. Akinbowale, Laboratory Assistant.
8. Abraham Showemimo, Laboratory Attendant.
9. K. S. Ekanem, Technical Assistant.
10. G. P. E. Ayuk, Technical Assistant.
11. S. O. Shiyanbola, Technical Assistant.
12. I. A. Orija, Driver/Mechanic.

NOTES ON APPENDIX II

Note 1.—All seed acquired prior to November, 1952 was transferred to West African Maize Rust Research Unit by the Department of Agriculture, Nigeria.

***Note 2.**—' Samaru ' is the Northern Region Research Station, Nigeria.

Note 3.—Rapid loss of viability due to bad drying condition, high storage temperature and humidities is a technical problem of the first magnitude when working under West African conditions.

Note 4.—Under good conditions the best local varieties yield 1200—1400 lb./acre. Average yield of rust susceptible local varieties is 700 lb. p.a.

‡Note 6.—Includes Botanist's, Nigeria Department of Agriculture, trials.

Note 7.—Key to symbols in polysora resistance column.

1 = very resistant.
2 = resistant..
3 = intermediate.
4 = susceptible.

Note 8.—Key to symbols in yield column.

— = no record.
† = poor.
†† = moderate.
††† = good.

Note 9.—Key to symbols in remarks column.

F = plot failed.
D = discarded from breeding programme.
M = multiplied for distribution.
N = no germination. (See Note 3.)
O = further observation required.
P = poor, not suited to West Africa.
Bs = Incorporated in breeding programme. Treatment *selection.*
Bi = Incorporated in breeding programme. Treatment *inbreeding.*
Bbc = Incorporated in breeding programme. Treatment *backcrossing.*
(As non-recurrent parent to incorporate polysora resistance into other varieties.)
Btc = Used in top-cross hybrids. One parent being polysora resistant, as a means of producing large quantities of material heterozygous *Rpp rpp.*
(*Rpp* is used to denote resistance to *Puccinia polysora.*
Rp is already in use for resistance to *Puccinia sorghi.*)

APPENDIX II

Maize seed received during the period covered by the report

No.	Acquisition Date	Country of Origin	Sender	Variety	Polysora resistance (field) Note 7	Yield estimat'd from primary observation trials Note 8	Yield from trials Note 4		Remarks Note 9
							No. of trials	Average lb/acre	
1	20/2/51	U.S.A.	Michigan State College (via Samaru*, Nigeria)	Mac. Yellow Flint	4	†	—	—	DF
2	23/2/51	South Africa	A. Ford and Co., Ltd., Johannesburg	Wisconsin White Dent	4	†	—	—	DP
3		Do.		American White Flint	4	†	—	—	DP
4		Do.		Cincinatti Bushman	4	†	—	449	DP
5		Do.		Natal 8 row (Yellow flint)	4	†	—	198	DP
6	Dec./1950	Canada	Macdonald College	Quebec	4	—	—	—	F
7		Do.		Pride of Saline	4	—	—	—	F
8	13/2/51	U.S.A.	Beltsville, Maryland (Mr. M. T. Jenkin)	Jellicourse	4	†††	—	—	Bs
9		Do.		Whatley Prolific	4	†††	—	—	Bs
10		Do.		White Tuxpan	4	†††	12‡	1368	Bs
11		Do.		Louisiana Yellow Flint	4	†††	—	—	D
12		Do.		Neal Paymaster	4	†††	—	—	D
14	Dec./1950	South Africa	via Rural Training Centre, Asaba, Nigeria	Big Joe	4	†††	1	438	Bs
15		Do.		Dixie 18	4	†††	2	1821	Bs
16	1941	Do.	Tsolo School of Agric. Cape of Good Hope	Tsolo	3	†††	32‡	1302	M
17	26/6/51	U.S.A.	Agric. Expt. Stn. N. Carolina	N.C. 27	4	††	1	1937	Bs
18		Do.		N.C. 1032	4	††	—	—	D
19		Do.		Jarvis Golden Prolific	4	††	—	—	D
20		Do.		Dixie 17	3	††	—	—	D
21		Do.		Latham Double	4	††	—	—	D
23	3/8/51	Canada	Ontario Corn Growers	White Cap	4	—	—	—	N
24		Do.	Marketing Board, Chatham	Golden Glow	4	—	—	—	N
25		Do.	Ontario	Wisconsin No. 7	4	—	—	—	N
26	Nov./1952		Botanist, Dept. of Agric., Ibadan, Nigeria	Mexican June	2–3	†††	2	1479	Bs
27				Louisiana White Tuxpan	4	(See Acq. 10)	—	—	Bs

No.	Acquisition Date	Country of Origin	Sender	Variety	Polysora resistance (field) Note 7	Yield estimat'd from primary observation trials Note 8	Yield from trials Note 4		Remarks Note 9
							No. of trials	Average lb/acre	
28	24/3/51	Canada	Dr. MacReatie, Guelph College, Ontario	De Kalb 56	—	—	—	—	P
29		Do.		Canada 355	—	—	—	—	P
30		Do.		Funks G.10	—	—	—	—	P
31		Do.		Funks G.77A	—	—	—	—	P
32		Do.		Pfister	—	—	—	—	P
33		Do.		Canada 696	—	—	—	—	P
34		Do.		Pioneer X 6124	—	—	—	—	P
35		Do.		Canada 645	—	—	—	—	P
36		Do.		Canada 275	—	—	—	—	P
37	11/9/51	Venezuela	via Agric. Attache American Embassy, Caraca, Venezuela	Venezuela I	2	††	—	—	Bs
38		Do.		Venezuela III	—	—	—	—	F
39		Do.		Seleçion	—	—	—	—	F
40		Do.		Sicaragua	2	††	15‡	1303	Bs, Bi, M
41	26/9/51	U.S.A.	Professor E. C. Rossman, Michigan State College	W.10	—	—	—	—	N
42		Do.		W.23	—	—	—	—	N
43		Do.		M.S.24A	—	—	—	—	N
44		Do.		M.S.206	—	—	—	—	N
45		Do.		W. 10 XM.S. 206	—	—	—	—	N
46		Do.		W. 23 XM.S. 24A	—	—	—	—	N
47	10/3/52	Australia	Department of Agric., Queensland	Golden Bounty	—	—	—	—	N
48		Do.	Do.	Improved Yellow Dent	4	—	1	908	D
49		Do.	Do.	Star Leaming	4	—	2	1049	D
50	May/1952	Kenya	Do.	Kitale Flat White Bot. No. 1	4	†††	2	1294	Bs
51		Do.	Do.	Hickory King 2	4	†	—	—	DP
52		Do.	Do.	Muratha Maize 3	4	†	1	907	DP
53		Do.	Do.	Common White Maize 4	4	†	—	—	DP
54		Do.	Do.	Kitumbili Maize 5	4	†	—	—	DP
55		Do.	Do.	African Grown Maize 6	4	†	—	—	DP
56		Do.	Do.	Natal Horse-tooth 7	4	†	—	—	DP
57		Do.	L. J. Nel	Hickory King 8	4	†	—	—	D
58		Do.	W. A. Bower, Eldoret	Kenya Hybrid 9	4	†	—	—	O
59		Do.	Do.	Hickory King 10	4	†	—	—	D
60		Do.	Ol Joro Oro	High altitude maize 11	4	†	—	—	DP
61		Do.	Do.	Blue variety 12	4	†	—	—	DP
62–65		Do.	Nieri Hill Farm	Kenya varieties 13–16	4	††	—	—	O

No.	Acquisition Date	Country of Origin	Sender	Variety	Polysora resistance (field) Note 7	Yield estimat'd from primary observation trials Note 8	Yield from trials Note 4		Remarks Note 9
							No. of trials	Average lb/acre	
66		Kenya	Nieri Hill Farm	Kenya varieties 17	4	†	—	—	DP
67–68		Do.	Do.	Do. 18, 19	4	††	—	—	Bs
69		Do.	L. J. Nel, Eldoret	Pochtesfroom Pearl	4	†	—	—	DP
70		Do.	Do.	Ladysmith White	4	†	—	—	DP
71	May/1952	Uganda	Kwanda Agric. Res. Stn.	Kenya 6	4	†	2	1500	D
72		Do.	Do.	Kenya 8	4	†	—	—	D
76		Kenya	Dept. Agric.	Kitale Flat White	4	†††	—	—	Bs
77–82		Sierra Leone	Dept. Agric.		—	—	—	—	D
83	10/6/52	Mexico	Rockefeller Research Centre	Mex. 1 Coahuila No. 8	1—2	†††	8‡	2095	Bs, Bi-Bbc, M
84		Do.		Mex. 2 Amarillo de Cuba	3	††	1	3109	Bs
85		Do.		Mex. 3 San Luis. Potosi 20	3	††	—	—	D
86		Do.		Mex. 4 Carmen	2	††	6‡	2298	Bs, Bi, Btc
87		Do.		Mex. 5 Rocamex 520 C	1—2	†††	3	3155	Bs, Bi–Bbc
88		Do.		Mex. 6 Blanco de Junio	3	††	1	1270	D
89		Do.		Mex. 7 Papaloapan	2—3	†††	6‡	2060	Bs
90		Do.		Mex. 8 Rocamex H.215	3	††	—	—	D
91		Do.		Mex. 9 Cielita (A)	3	†	3	581	D
92		Do.		Mex. 10 Rocamex H—309B	3	†	—	—	D
93		Do.		Mex. 11 Do. H—311	3	†	—	—	D
94		Do.		Mex. 12 Do. H—1	3	†	—	—	D
95		Do.		Mex. 13 S.L.P. 20—4A	1	†††	3	1912	Bi, cont., Bbc, Btc
96		Do.		Mex. 14 S.L.P. 20—388	3	††	1	1910	D
97		Do.		Mex. 15 Coah 8—56A	3	††	2	1830	D
98		Do.		Mex. 16 Ver. 39—66B—1	1—2	††	2	990	Bi, cont., Bbc, Btc.
99		Do.		Mex. 17 S.L.P.20—34A—2	1	††	—	—	Bi, cont. Bbc, Btc.
100		Do.		Mex. 18 Coah 8—15A–1–1	3	††	1	1722	D
101		Do.		Mex. 19 L. 11 110—5 X Ver. 19–2–1–1–2–4	3	†	—	—	D
102		Do.		Mex. 20 B1–82–2–3 X S.L. P.20–71A–1–2	3	††	2	1301	D
103		Do.		Mex. 21 M. 30–60–3 X Ver. 28–29A	2	††	5	1503	Bs
104		Do.		Mex. 22 L11 123–2–1–8 X Coah 8–56A–4–2	2	††	2	1484	Bs

No.	Acquisition Date	Country of Origin	Sender	Variety	Polysora resistance (field) Note 7	Yield estimat'd from primary observation trials Note 8	Yield from trials Note 4		Remarks Note 9
							No. of trials	Average lb/acre	
105	10/6/52	Mexico	Rockefeller Research Centre	Mex. 23 L11. 126. 5–6 X Ver. 39–66B–1–4	3	††	—	—	D
106	Oct./1952	Malaya	Department of Agric. Malaya	Malaya Red Flint	4	†	2	1448	D
107		Do.		Malaya Yellow Flint	4	†	1	136	D
108		Kenya		Korontari Maize	4	†	1	1208	D
109		Do.		Maize from D. Farm	4	†	—	—	D
111		Do.		Maize from Ol. Joro	4	†	—	—	D
113		Do.		Sierra Leone Varieties					D
114									
118–122	7/11/52	India	Agric. Dept., Poona, India	Indian Varieties	4	†	—	—	D
123		Do.		Duahmoger	4	†	—	—	D
124		Do.		White Velda	4	†	1	944	D
125		Do.		Red Velda	4	†	—	—	D
126		Do.		Sarawah	4	†	—	—	D
127		Do.		Arwhari	4	†	—	—	
128		Ceylon		Ma-Ha-Oya	4	†	—	—	D
129		Do.		Wellawaya	4	†	—	—	D
130		Do.		Ma-ha-Oya	4	†	—	—	D
131		Do.		Embillipituya	4	†	—	—	D
132		Do.		Tamankaduwa	4	†	—	—	D
133		Do.		Batticola	4	†	—	—	D
135		Do.		Manewa	4	†	—	—	D
136		Mauritius	Pamplemouses Exp. Stn.	Mauritius	3	††	2	960	Bs
137		Do.	Do.	Kenya 21	2—3	†††	—	—	Bs
	Note (1)								
138–141	18/11/52	India	Dept. of Agric., Madras	Indian Varieties	4	†	—	—	D
142	Nov./1952	Do.	Agric. Research Institute, Delhi, (New Delhi)	Meerut Yellow	4	†	—	—	D
143		Do.		Kampur	4	†	—	—	D
144		Do.		Pusa Yellow	4	†	2	1003	D
145–157	24/11/52	Guatemala	Iowa State College, Tropical Research Centre		1—2	?	—	—	F
180–272	12/6/53	Trinidad Br.	Imperial Coll. of Tropical Agric. Trinidad (via W.A.I.T.S., Accra)	Trinidad lines	?	?	—	—	O
274–305	19/10/53	South Africa	Dr. J. E. Vanderplank	South African lines	4?	?	—	—	(See 50–76).

APENDIX III

SEED DISTRIBUTION LIST

Seed has been sent out to the following territories :

BRITISH ADMINISTERED TERRITORIES

WEST AFRICA : Gold Coast
Nigeria
Sierra Leone

EAST AFRICA : Kenya (from whence lines derived from West African Maize Rust Research Unit Distribution have been distributed to Territories within the East African Forestry and Research Organisation).

CENTRAL AFRICA : Southern Rhodesia

INDIAN OCEAN : Mauritius

OTHER TERRITORIES

Belgian Congo
Dahomey
French Equatorial Africa
Lourenço Marques
Réunion

APPENDIX IV

Notes on the Behaviour of Selected Maize Lines

Acq. No. Note 6	Pro. No. Note 7	PARENTAL LINE	PLANT CHARACTERS				AGRONOMIC DATA Note 10, 11				GRAIN CHARACTERS				OTHER CHARACTERS Note 11		
			TASSEL COLOUR	STEM COLOUR	LEAF COLOUR	LEAFY APPENDAGES Note 1	EAR SHEATH Note 2	SHELLING OUT PER-CENTAGE	HEIGHT IN METRES	TIME TO MATURITY (days)	TYPE	COLOUR	EAR LENGTH	ROW No. OF GRAIN	HEL Note 3	OP Note 4	SMUT Note 5
													Inches				
83	288	Mexican 1*	Gr.	Gr.	All Dk. Gr.	+	Lr.	75	2·5	98	De.	W.	10	14	(†)	(†)	—
86	265	Mexican 4	Gr.	Gr.		0	Lr.	77	2·7	79	De.	W.	9	12	†	†	—
87	249	Mexican 5*	Gr.	Gr.		0	Lr.	55	2·6	98	De.	W.	8	14	†	(†)	—
95	306	Mexican 13	Gr.	Gr.		0	Lr.	55	2·6	82	De.	D.Y.	10	13	†	(†)	—
98	117	Mexican 16	L.Gr.	Gr.		+	Lr.	67	2·5	109	De.	W.	10	14	(†)	†	—
99	239	Mexican 17	Gr.	Gr.		0	Lr.	61	1·7	108	Ft.	Y.	6	12	†	†	—
117	97	Cuba Amarillo	Gr.	Gr.		0	Lr.	67	2·3	81	Ft.	L.Y.	8	14	(†)	†	—
Bot.	341	La Creole	Gr.	Gr.		0	Lr.	61	3·0	81	Ft.	Y.	9	15	(†)	†	—
40	204	Sicaragua * Note 9	Gr.	Gr.		0	Sh.	60	2·4	82	De.	W.	7	14	(†)	†	—
64	255	Kenya 15	Gr.	Gr.		0	Lr.	62	2·3	91	Ft.	Y.	9	14	—	†	—
67	263	Kenya 18	Gr.	D.Gr.		+	Lr.	69	2·5	98	De.	W.	9	15	(†)	†	—
65	278	Kenya Flat Yellow	Gr.	Gr.		+	Lr.	65	2·7	83	Ft.	L.Y.	8	14	†	(†)	—
15	327	Tsolo	Gr.	Gr.		+	Lr.	66	2·2	98	Ft.	D.Y.	10	14	††	††	†
10	257	White Tuxpan	Gr.	Gr.		0	Lr.	71	2·8	98	De.	W.	8	15	(†)	†	—
—	148	Yellow Bounty (Note 8)	Gr.	L.Gr.		+	Lr.	61	2·8	93	Ft.	Y.	9	12	(†)	(†)	††
—	74	Yellow Bounty × Mexican 4	Gr.	Gr.		0	Sh.	70	2·2	79	De.	L.Y.	9	14	†	†	—
—	102	Yellow Bounty × Mexican 7	Gr.	Gr.		0	Lr.	69	2·7	79	De.	L.Y.	8	14	(†)	†	—
—	103	Yellow Bounty × Cuba Amarillo	Gr.	Gr.		0	Lr.	67	2·9	83	De.	L.Y.	9	14	—	†	(†)
—	195	Sicaragua × Cuba Amarillo	Gr.	Gr.		0	Sh.	59	2·7	77	De.	L.Y.	9	14	—	†	—
—	110	Mauritius × La Creole	Gr.	Gr.		0	Lr.	67	2·8	81	Ft.	D.Y.	10	15	—	†	—

* Recommended to the West African Departments of Agriculture.

Key to abbreviations

1. D. = Dark
2. De. = Dent
3. Ft. = Flint
4. Gr. = Green
5. L. = Light
6. Lr. = Longer
7. Sh. = Shorter
8. W. = White
9. Y. = Yellow

(White flour type followed by white dent is local preference.)

Key to Notes 3, 4, 5.

Degree of infection :—

— = Nil
(†) = Trace
† = Light infection
†† = Heavy infection

Notes

Note 1+ Indicates leaf blades on the ear sheaths.

Note 2. It is desirable to have adequate close sheathing of the ear to avoid insect and bird damage to the grain.

Note 3, 4, 5. Indicate attack of *Helminthosporium turcicum*, *Ophiobolus heterostrophus* and *Ustilago zeae* respectively.

Note 6, 7. West African Maize Rust Research Unit, Acquisition number and Progeny (family) number respectively.

Note 8. A variety bred by Botanist, Department of Agriculture, Nigeria, from a top cross of local and U.S.A. varieties.

Note 9. The cob after shelling is red. Viz. : homozygous *Pwr* (White pericarp, red cob) and is easily distinguished from the Mexican series by this gene.

Note 10. All the varieties are resistant to lodging.

Note 11. A punched card system is being adopted for the classification of agronomic characters, pest and disease resistance.

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